AN ACTUATION SYSTEM COMPRISING A DIGITAL POSITION SENSOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a system for actuating a member and ~~also to~~ methods of ~~actuating~~ using the system to actuate the ~~a~~ member ~~using such a system~~.

_The invention also relates to ~~the use of such a~~using the system for actuating a device ~~for metering~~to meter fuel in a heat engine, ~~in particular in~~such as, for example, an aeronautical turbine engine.

2. Description of Related Art

[0002] ~~In the context of this use, i~~It is known to use an actuating system comprising an electric motor, for example, ~~of the~~a stepping-type electric motor, which ~~comprises~~ includes a device for transmitting the movement of the electric motor to a valve ~~for supplying~~that supplies fuel to the heat engine. The electric motor is controlled by a computer that is ~~that is designed~~configured to regulate the current ~~with which~~supplied to the electric motor ~~is supplied~~ as a function of a ~~position~~ setpoint position of the valve ~~which~~. The setpoint position is derived from ~~the~~ an acceleration command initiated by the pilot of the plane having the heat engine, ~~so as~~ to supply a desired amount of fuel to the heat engine ~~with the desired amount of fuel~~.

[0003] It has been proposed to make such ~~an~~ actuation safer by comparing the actual movement of the electric motor ~~and the~~with a movement ~~that corresponds in theory~~corresponding, theoretically, to the applied setpoint, ~~so as~~ to detect, in real time, any anomaly in the actuation ~~anomaly~~.

[0004] To ~~do~~ accomplish such~~this~~, it has been proposed to measure the actual movement of the electric motor using a ~~sensor of the resolver type~~resolver-type sensor, which delivers information about the absolute angle of the rotor of the electric motor in the form of analog~~ue~~ signals.

[0005] The integration of a ~~this type~~resolver-type ~~of~~ sensor in an actuating system poses many problems. ~~This is because sensors of the~~For example,

~~resolver type~~resolver-type sensors are particularly bulky and relatively heavy ~~on account of~~due to the technology used to provide the sensors, which requires a rotor and a stator that may ~~be composed of~~have a number of wire windings ~~formed of wires~~ wound around a metal ~~carcass~~core.

[0006] Moreover, the volume needed ~~for their integration~~to integrate the resolver-type sensors often requires the~~m to~~ sensors be mounted on a rotor parallel to ~~that of~~ the electric motor. Consequently, particularly in the case of small actuating systems, the sensor becomes as bulky ~~as contributes to~~component of the electric motor and significantly contributes to the total mass of the actuating system.

[0007] Furthermore, since the position information delivered by the resolver-type sensor is ~~of an~~ analog~~ue~~ in nature, the actuating system must ~~comprise~~ include an analog~~ue~~/digital conversion stage at the input of the computer ~~so as to be able~~ to make use of ~~said~~ the position information.

[0008] Moreover, particularly in the context of the use under consideration, it is indispensable to obtain reliable and precise actuation, and to do so under use conditions that are severe in terms of vibrations, temperatures and pressures.

[0009] ~~Sensors of the resolver type~~Resolver-type sensors do not optimally satisfy the constraints, particularly in terms of reliability, ~~on account of~~due to the large number of elements of which they are composed and the presence of an additional analog~~ue~~ /digital conversion stage within the computer~~, do not optimally satisfy these constraints, particularly in terms of reliability~~.

[0010] The same is true of ~~sensors of the~~ resistive-~~-~~type sensors, the reliability of which is highly affected by severe use conditions.

BRIEF SUMMARY OF THE INVENTION

[0011] ~~The~~ It is an aspect of the present invention ~~aims~~ to ~~solve all of~~address the above-mentioned problems. ~~mentioned above by proposing~~ in particular, it is an aspect of the present invention to provide an actuating system which ~~has means that~~ delivers, in a precise and reliable manner, position information ~~that is~~ representative of the movements of the electric motor~~, said~~. The position information ~~being~~ is in the form of digital signals and ~~it being possible for said~~

~~means to be~~the system which delivers the information is easily integrated into the actuating system.

[0012] ~~For this purpose, and a~~According to ~~a first~~another aspect of the present invention, ~~the invention proposes~~ an actuating system ~~of the type comprising~~is provided, which includes an electric motor controlled by a computer ~~that is designed~~configured to regulate the current supplied to the electric motor as a function of a ~~position~~ setpoint position of the member that is to be actuated~~, said~~. The actuating system ~~comprising~~ also includes a device for transmitting the movement of the electric motor to the member~~, in which t~~. The transmission device ~~comprises~~ includes an encoder that is dependent on the movement of the electric motor~~, said~~. The encoder ~~comprising~~ includes a main multipolar track~~, and t~~. The system ~~comprising:~~further includes

a fixed sensor ~~comprising~~ having at least two sensitive elements ~~that are~~ arranged ~~facing and at an air-gap distance from~~to face the main track with an air-gap ~~,~~between the elements and the main track. ~~said~~The fixed sensor ~~being~~ is designed to deliver two square digital position signals ~~A, B~~ in quadrature ~~which are~~and representative of the position of the encoder~~;~~.

~~-a~~A device for ~~-~~processing the signals ~~A, B, which device comprises~~includes counting means for determining, from an initial position, the actual position of the encoder~~;~~.

\- ~~a~~ A device ~~for comparing~~compares the actual position of the encoder with the position of the encoder that corresponds, in theory, to the applied setpoint.

[0013] According to one embodiment of the present invention, the comparison device ~~comprises~~ includes alert means which, upon determination of a significant difference between the actual position and the theoretical position, ~~are~~ is designed to emit a signal indicating an anomaly in the operation of the actuating system.

[0014] According to ~~a second~~ another aspect, the present invention ~~proposes~~ includes a method of actuating a member using ~~such an~~the actuating system~~, which~~. The method ~~comprises~~ includes the ~~provident~~ iterative steps of~~:~~

_~~applying to~~inputting the ~~computer a position~~ setpoint position of the member to the computer; ~~;~~

determining the actual position of the encoder;

_comparing the actual position of the encoder with the position of the encoder ~~that corresponds~~corresponding, in theory, to the applied setpoint; and

~~-if~~activating the alert means when the difference between the actual position and the theoretical position is greater than a ~~threshold, activating the alert means~~predetermined threshold amount.

[0015] According to another embodiment of the present invention, the comparison device ~~comprises~~ includes an actuation feedback loop~~, which is~~ controlled as a function of the determined difference between the actual position and the theoretical position.

[0016] According to a third aspect, the present invention ~~proposes~~ includes a method of actuating a member using ~~such an~~ the actuating system~~, which~~. The method ~~comprises~~ includes the ~~provident~~ iterative steps of~~:~~

_~~applying~~ inputting ~~to~~ the ~~computer a position~~ setpoint position of the member to the computer;

_determining the actual position of the encoder;

_comparing the actual position of the encoder with the position of the encoder ~~that corresponds~~corresponding, in theory, to the applied setpoint; and

~~if the difference between the actual position and the theoretical position is greater than a threshold,~~ controlling the feedback loop ~~so as to apply to the computer~~wherein a ~~position~~ setpoint position ~~that is slaved to~~associated with the difference between the actual position and the theoretical position is supplied to the computer when the difference is greater than a predetermined threshold amount.~~.~~

[0017] According to ~~a fourth~~yet another aspect of the present invention, the ~~invention proposes the use of an~~ actuating system is used to actuate ~~according to the invention for actuating~~ a device for metering fuel in a heat engine.

[0018] Other aspects and advantages of the invention will emerge from the following description, given with reference to the appended drawings~~, in which:~~.

BRIEF DESCRIPTION OF THE DRAWINGS

-[0019] ~~figures 1 and 2 are functional~~FIGs. 1-2 are schematic diagrams of a rotating actuating system ~~for actuating in rotation respectively~~ according to a first and a second embodiment of the present invention;

-[0020] ~~figures 3a and 3b~~FIGs. 3a and 3b are ~~functional~~ schematic diagrams illustrating overhead and side views, respectively, of a translation actuating system ~~for actuating in translation~~ according to another embodiment of the present invention~~, respectively seen perpendicular and parallel to the axis of actuation~~;

-[0021] ~~figure 4~~FIG. 4 is a longitudinal section view ~~in longitudinal section~~ of an actuating system for a device ~~for metering~~that meters fuel in a heat engine; and

-[0022] ~~figure 5~~FIG. 5 is a sectional view ~~in section on~~taken along line V-V of ~~figure~~ FIG. 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023] The invention relates to an actuating system comprising an electric motor 1, for example, ~~of the stepping~~a stepper-~~-~~type motor, which is controlled by a computer 2 ~~that is designed~~configured to regulate ~~the~~ a current supplied to the motor 1 as a function of a setpoint position of a member to be actuated.

[0024] The ~~system is intended to actuate a~~ member is actuated by ~~via~~ a device ~~for~~ which ~~transmitting~~ transmits the movement of the motor 1 to ~~said~~ the member to be actuated. The actuation is ~~then~~ obtained by controlling the motor 1 with a ~~position~~ setpoint position of the member ~~that is~~ to be actuated, ~~said~~ the setpoint position being ~~designed~~selected, ~~depending~~ based on the ~~nature~~ type of the transmission device used, to move the member ~~into the~~to a desired position.

[0025] In one ~~particular~~ exemplary use, the actuating system ~~is intended to~~ actuates a device ~~for metering~~which meters an amount of fuel provided to a heat engine, such as, for example, ~~in particular~~ an aeronautics turbine. For this purpose, ~~the~~ a transmission device ~~makes it possible to actuate~~facilitates actuating a valve ~~for supplying~~which supplies fuel to the heat engine, ~~and~~

wherein the setpoint position is derived from ~~the~~ an acceleration command ~~which is actuated~~ provided by the pilot flying the plane having the heat engine.

[0026] In order to ~~know the~~determine an actual movement of the transmission device that is induced by the setpoint, an encoder 3, having a main multipolar track M that is dependent on the movement of the motor 1, is ~~the invention proposes~~ integrat~~ing~~ed into the actuating system ~~an encoder 3 provided with a main multipolar track that is dependent on the movement of the motor 1,~~ and a sensor 4, ~~that~~ which can deliver two digital signals ~~which are~~ representative of the position of ~~said~~ the encoder 3, and hence, of the movements of the electric motor 1.

[0027] In one ~~particular example~~exemplary embodiment, the encoder 3 is formed of a multipolar magnetic part on which ~~there is magnetized~~ a plurality of magnetized pairs of north and south poles are equally distributed with a constant angular width ~~so as~~between neighboring poles to form the main track M. In ~~one example of~~another exemplary embodiment, the encoder 3 is formed of an elastomeric part which is charged with magnetic particles, such as, for example, with ferrite, such as barium ferrite or strontium ferrite.

[0028] The sensor 4 is fixed and ~~comprises~~ includes at least two sensitive elements that are arranged ~~facing~~ to face the main track M with ~~and at~~ an air-gap ~~distance from~~AG defined between the sensitive elements and -the main track M, ~~so as~~ to deliver two periodic electrical signals S1, S2 in quadrature. The sensor 4 also ~~comprises~~ includes means for digitizing the signals S1, S2, ~~so as to deliver~~wherein two square digital position signals A, B are delivered in quadrature, wherein the signals ~~which~~ are representative of the position of the encoder 3.

[0029] In one ~~particular example~~exemplary embodiment, the sensitive elements are chosen from ~~the~~ a group ~~comprising~~ including Hall probes, magnetoresistors and giant magnetoresistors.

[0030] The ~~principle of obtaining~~manner in which the signals S1 and S2 are obtained from ~~a~~ the plurality of ~~aligned~~ sensitive elements is described, for example, in ~~the document~~Applicant's FR-2 792 403 ~~by the Applicant~~. In

particular, this embodiment makes it possible to obtain position signals which do not depend on the amplitude of the read magnetic field; ~~and~~ which are ~~therefore~~ insensitive to the air-gap variations due to the movement of the encoder 3; and which are also insensitive to the decrease in the magnetic field due to the temperature.

[0031] However, sensors 4, ~~comprising~~ having two sensitive elements that ~~can~~ deliver the signals S1 and S2, are ~~also~~ known.

According to one embodiment, as described, for example, in ~~the document~~ FR-2 754 063 ~~by the Applicant~~, the sensor 4 ~~comprises~~ includes means for interpolating the signals which make it possible to increase the resolution of the output digital signals A, B, so as to be able to use a smaller number of pairs of poles. Thus, it is possible to use a high level of magnetic induction, ~~and this makes~~wherein it becomes possible to increase ~~on the one hand~~ the robustness of ~~operation of~~ the actuating system's operation with respect to the severe use conditions ~~and on the other hand~~as well as the resolution of the position signals, and to do so without increasing the bulk of the encoder 3.

[0032] The actuating system further~~more comprises~~ includes a device for processing the signals A, B, ~~which~~ the device ~~comprises~~ including counting means for determining, from an initial position, the actual position of the encoder 3.

[0033] In one ~~example of~~exemplary embodiment, the counting means ~~comprise~~ includes a register ~~in~~ within which the value of the position of the encoder 3 is ~~incremented~~ increased or ~~decremented~~ decreased by ~~a~~ an incremental value corresponding to the number of fronts of ~~the~~ signals A, B ~~that~~ which are detected.

[0034] As shown in FIGs. 1, 2, 3a and 3b, t~~T~~he sensor 4 and the processing device 5 may be integrated and provided on a silicon substrate or the like, for example, an AsGa substrate, ~~so as~~ to form an integrated circuit ~~that is~~ customized for a specific application, ~~which~~ wherein the circuit is sometimes referred to as an ASIC to denote an integrated circuit that is designed in whole or in part as a function of requirements.

[0035] According to a first embodiment, the initial position is fixed at zero when the actuating system is set in operation. Thus, the processing device 5 ~~makes it possible to know~~enables the relative position of the encoder 3 with respect to the initial position to be known~~, that is to say~~. In other words, the distance separating the position of the encoder 3 from any initial position, which may vary with respect to a fixed ~~referential~~reference point.

[0036] According to a second embodiment, the processing device 5 is designed to deliver the absolute position of the encoder 3. ~~absolute~~ Absolute position is understood to mean the distance separating the position of the encoder 3 at a given instant from a reference position of the encoder 3~~, this given~~ with respect to a fixed ~~referential~~reference position. For this purpose, the system ~~comprises~~ includes means for determining a reference position, and the processing device 5 ~~comprises~~ includes means which, upon detection of ~~said~~ the reference position, ~~can~~ assigns ~~said~~ the reference position as the initial position.

[0037] According to ~~a~~ the first embodiment, the means for determining the reference position ~~are~~ is integrated in the encoder 3. For this purpose, the encoder 3 ~~furthermore comprises~~ also includes a singularity that is indexed to a reference position of the encoder 3~~, and t~~. The sensor ~~furthermore comprises~~also includes at least one sensitive element designed to detect ~~said~~ the singularity of the encoder 3. In particular, the encoder 3 may ~~comprise~~ include the main multipolar track M or a top tour track T, the ~~that is referred to as the "top tour" track, said~~ track M or T being provided with the singularity~~, a~~. At least one sensitive element ~~being~~ is arranged ~~facing and at an air-gap distance from said "top tour" track so as~~to face the track M or T across the air-gap AG defined between the sensitive element and the track M or T to deliver a digital signal C ~~that comprises~~having a pulse. The processing device 5 ~~then comprises~~includes means which, upon detection of the pulse, ~~can~~ assigns the reference position as an initial position. ~~One principle~~An exemplary manner of obtaining the digital signals A, B and C, and ~~also various ways of~~various ways of realizing a magnetic singularity, are described in ~~the documents~~ FR-2 769 088 and EP-0 871 014. In particular, the magnetic singularity of the ~~"tour"~~ track M or

T may be formed of two adjacent poles, the magnetic transition of which is different from the others.

[0038] According to a second embodiment, the means for determining the reference position are integrated in the transmission device. For this purpose, the transmission device may ~~comprise~~ include a stop that is designed to interrupt the movement of the motor 1 in a reference position of the encoder 3, and the processing device 5 may ~~comprise~~ include means which, upon interruption of the movement, ~~can~~ assigns the reference position as the initial position.

[0039] Although the description is given in relation to an encoder/magnetic sensor assembly, it is also possible to implement the invention analogously using an equivalent technology, such as, for example, ~~of~~ the optical type. For example, the encoder 3 may be formed of a metal or glass target on which the main track M and possibly the ~~"~~top ~~tour"~~ track T have been engraved ~~so as~~ to form an optical motif that is analogous to the multipolar magnetic motif described above, the sensitive elements then being formed of optical detectors.

[0040] The actuating system ~~furthermore comprises~~also includes a device 6 for comparing the actual position of the encoder 3, that is to say the position determined by the processing device 5, with the position of the encoder 3 that corresponds, in theory, to the applied setpoint. The comparison device 6 thus makes it possible to make the actuation safer by verifying, in real time, the correspondence between the movements of the electric motor 1 and the setpoint applied to the computer 2.

[0041] In ~~one particular example~~an exemplary embodiment and as shown in FIGs. 1, 2, 3a and 3b, the comparison device 6 is integrated ~~in~~ or provided within the computer 2 and ~~comprises~~ includes a comparator for making a comparison between the position signal coming from the processing device 5 and the position signal derived from the setpoint~~, t~~. The integration being particularly simple and reliable on account of the digital nature of the two types of signal.

[0042] According to ~~a first embodiment~~another exemplary embodiment, the comparison device 6 ~~comprises~~ includes alert means which, upon determination of a significant difference between the actual position and the theoretical position,

~~are~~ is designed to emit a signal, for example, a light signal or audible signal, indicating an anomaly in the operation of the actuating system.

[0043] The method of actuating the member using such an actuating system ~~then comprises~~includes the ~~provident~~ following iterative steps of~~:~~

~~applying to the computer 2~~ inputting a ~~position~~ setpoint position of the member to the computer 2; determining the actual position of the encoder 3;

-comparing the actual position of the encoder 3 with the position of the encoder 3 that corresponds, in theory, to the applied setpoint; and,

if the difference between the actual position and the theoretical position is greater than a predetermined threshold value, activating the alert means.

[0044] According to ~~a second embodiment~~another exemplary embodiment, the comparison device 6 ~~comprises, possibly~~includes, in addition to the alert means, an actuation feedback loop, which is controlled as a function of the determined difference between the actual position and the theoretical position. Thus, any anomaly in the operation of the actuating system ~~can be~~is corrected by controlling the system in real time ~~so as~~ to position the encoder 3 in the setpoint position ~~corresponding to the setpoint~~. As a ~~variant~~modification to this embodiment, the processing device 5 may ~~also be able to~~ deliver signals which are representative of the speed of displacement of the encoder 3, ~~it being possible for said~~ with the signals ~~to be~~being used in the feedback loop.

[0045] The method of actuating the member using such an actuating system ~~then comprises~~includes the ~~provident~~ following iterative steps of~~:~~

~~-applying to the computer 2~~inputting a ~~position~~ setpoint position of the member to the computer 2;

determining the actual position of the encoder 3;

comparing the actual position of the encoder 3 with the position of the encoder 3 that corresponds, in theory, to the applied setpoint; and,

if the difference between the actual position and the theoretical position is greater than a predetermined threshold value, controlling the feedback loop so as to apply to the computer 2 a position setpoint that is slaved to the difference.

[0046] In the ~~two~~ exemplary embodiments described above, the methods may, where appropriate, ~~comprise~~ include a step prior to the ~~prior procedure of~~ step of determining the initial position of the encoder 3. In particular, when the actuating system is ~~set~~ in operation, the procedure may ~~envisage~~ include a step of supplying the motor 1 with a current ~~so as~~ to position the encoder 3 in ~~its~~ a reference position, ~~said~~the reference position being assigned in the processing device 5 as an initial position~~, so as~~ to subsequently determine the absolute position of the encoder 3.

[0047] With reference to ~~figures 1 and 2~~FIGs. 1-2, a description is given of a system for actuating a member in rotation.

[0048] According to the embodiment of ~~figure 1~~FIG. 1, the transmission device ~~comprises~~ includes the rotor 7 of the electric motor 1, wherein the encoder 3 ~~being~~ is mounted on a part of ~~said~~ the rotor that is opposite the member that is to be actuated.

[0049] According to the embodiment of ~~figure 2~~FIG. 2, the transmission device ~~comprises~~ includes a two-stage reducer 8, the encoder 3 being mounted on the output rotor 9 of ~~said~~ the reducer. As a ~~variant~~modification to such an embodiment, the encoder 3 may also be mounted on the rotor 7 of the electric motor 1 or on the input rotor 10 of the reducer 8.

[0050] In these two embodiments, the encoder 3, and hence, the 30 multipolar tracks, are circular, ~~said~~ the encoder being, for example, annular in shape and ~~comprising~~ including a bore that allows it to be connected to the rotor 7, 9.

[0051] With reference to ~~figures~~ FIGs. 3a and 3b, a description is given of a system for actuating a member in translation. For this purpose, the transmission device ~~comprises~~ includes the rotor 7, which is provided with a pinion 11 and a part 12 provided with a rack 13, which are designed to transform the rotary movement of the rotor 7 into a linear movement of the part 12, the encoder 3 being associated with ~~said~~ the part. As a ~~variant~~modification, the ~~10~~ part 12 may form part of the member that is to be actuated.

[0052] In this embodiment, the encoder 3, and hence, the multipolar tracks, are linear, ~~said~~ the encoder being, for example, molded with the part 12.

[0053] With reference to ~~figures~~ FIGs. 4 and 5, a description is given of an actuating system for a device for metering fuel in a heat engine, which corresponds to the functional diagram of ~~figure~~ FIG. 2. For this purpose, the output rotor 9 ~~comprises~~ includes a slot into which there is designed to be inserted the valve for supplying fuel to the metering device (not shown).

[0054] The actuating system ~~comprises~~ includes a casing 14 in which the motor 1 and the reducer 8 are housed ~~so as~~ to form a single assembly.

[0055] The encoder 3 is fixed to an annular journal 15 of the gear wheel 16 which is associated with the output rotor 9. This embodiment ~~makes it possible to integrate~~permits integration of an encoder 3 having a large diameter, which makes it possible to improve the precision with which the position of ~~said~~ the encoder is measured without increasing the size of the actuating system or requiring additional mechanical parts.

[0056] The sensor 4 is formed of a non-magnetic structural part in which the sensitive elements and the associated electronics are housed, the input/output connection of the sensor 4, which is formed of a multiconductor cable 17, projecting from ~~said~~ the part ~~so as~~ to allow ~~in particular~~ the connection of ~~said~~ the sensor 4 to the computer 2.

[0057] The non-magnetic structural part ~~comprises~~ includes a head 4a on a side face of which there extends a body 4b, the sensitive elements being disposed in the vicinity of the free side face 4c of the body 4b and the cable 17 extending from the side face of the head 4a that is opposite the body 4b. The part is designed so that the head 4a has, on the body side, a free side surface 4d.

[0058] The sensor 4 is fixed in a housing 18 of the casing 19 of the reducer 8, ~~said~~ the housing being designed to receive the body 4b by pressing the free side surface 4d against the peripheral wall of ~~said~~ the housing. Thus, the sensitive elements are ~~placed~~ precisely and reliably positioned to ~~facing~~ face ~~and at~~the encoder 3 across an air-gap ~~distance from the encoder 3 so as~~ defined therebetween to be able to withstand ~~the~~ severe use conditions. Furthermore, a

wedge 20 may be placed between the peripheral wall of the housing and the free side surface 4b ~~so as to be able~~ to regulate the air-gap distance.